ULTRASONIC WELDING PROCESS AND EQUIPMENT FOR CONSTRUCTION OF ELECTRON-TUBE MOUNTS

Fourteenth Quarterly Progress Report
For the Period
October 1 through December 31, 1965

Contract No. DA-36-039-sc86741
Order No. 19063-PP-62-81-H

Placed by
Industrial Engineering Division
United States Army Electronics Command
225 South Eighteenth Street
Philadelphia, Pennsylvania

AEROPROJECTS INCORPORATED
West Chester, Pennsylvania

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The object of this program is to design and construct prototype welding equipments and their associated accessories to perform by ultrasonic techniques the welding operations required in the assembly of electron tubes.

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Specifications SCS-114A, ECIPPR-15
and MIL-E-1/1121A

Report Prepared by: J. W. Thomas

Report Approved by: Byron Jones

ABSTRACT

Fabrication of a second sample lot of 100 type 6080WB electron tube mounts was successfully completed. Of 175 tube mounts started, 118 were completed up to the bulbing and basing operations. The final connection in the assembly sequence (snubbers to snubber support rods) was made by resistance welding, in order to utilize the more fragile alumina spacer now used in the 6080WB electron tube.

The incidence of short circuits between the grid laterals and the cathode sleeve was eliminated by insertion of a steel mandrel in the cathode sleeve prior to welding. A testing schedule was agreed upon at a meeting between representatives of Aeroprojects, Tung-Sol, and the Production and Procurement Directorate. Testing will be initiated as soon as bulbing and basing are completed.

The 4-kw ultrasonic welder was delivered to a Government agency selected by the USAECOM.

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PURPOSES

The objectives of this Production Engineering Measure (PEM) are to:

1. Demonstrate the capability limits of ultrasonic welding to join combinations of metallic materials of interest to the electron-tube industry. Devote major effort to making satisfactory joints in materials and geometries which might be difficult or impossible to join by other means.

2. Analyze the welding requirements for a specific electron tube - Type 6080WB. This type was selected by the U. S. Army Electronics Command because it has a record of rejects and failures due to metallic splatter caused by conventional welding techniques and improperly welded joints.

3. Redesign components of the Type 6080WB electron-tube where possible, to permit ultrasonic welding of joints previously found impractical. This effort will result in a tube mount with as many metal-to-metal joints as possible produced by ultrasonic welding so that evaluation of electron-tube performance will not be confused by the influence of metal-to-metal joints produced by other welding or joining techniques.

4. Determine the feasibility of joining 0.003-inch gold-plated molybdenum grid wires to 0.060-inch molybdenum side bars by ultrasonic welding for frame grid manufacture. If successful, redesign applicable components of the Type 6080WB electron-tube mount to permit the use of frame grids.

5. Prepare fixturing and tooling for the Type 6080WB electron tube, compatible with ultrasonic welding equipment.

6. Ultrasonically weld the parts required to assemble electron-tube mounts for the 6080WB tube type, and compare results obtained against similar sub-assemblies made by conventional joining methods. Tests will include strength and environmental tests.

7. Build production ultrasonic welding equipment which will enable an electron-tube manufacturer to make the welded connections in a broad range of electron-tube types.

8. Install the ultrasonic welding equipment in a production company, and produce on a pilot basis with that company's personnel a limited lot size of Type 6080WB electron tubes for subsequent evaluation in accordance with the applicable military specification.

NARRATIVE AND DATA

I. ELECTRON TUBE STUDY

A. Fabrication of Sample Lot

During this period, a second sample lot of 100 Type 6080WB electron tube mounts was fabricated. Fabrication of 175 mounts was initiated November 9, with material prepared according to the revised annealing procedures specified in the latest parts list (Thirteenth Quarterly Progress Report). Total shrinkage was 57 mounts. The history of the sample lot, with reasons for rejections at the various stages of the assembly sequence, is summarized in Table I. Of the 57 rejections, only 16 can be directly attributed to ultrasonic welding. Fabrication of 118 satisfactory mounts was completed November 22. During the fabrication effort, Aeroprojects provided continuous technical assistance to Tung-Sol.

The 118 satisfactory mounts were released to the Tung-Sol factory for bulbing, basing, and preliminary electrical testing. Provided that a satisfactory yield is obtained from this lot after factory operations and testing, sufficient tubes will be available for initiation of the formal testing program.

The sample lot was prepared with connections between snubbers and snubber support rods made by resistance welding. Experience in fabricating the first sample lot had shown that the alumina (AlSiMag) spacer now used in the construction of the 6080WB tube is too fragile to permit ultrasonic welding of this connection. The breakage of the alumina spacers was observed by Mr. H. Shienbloom of USAECOM during a visit to Tung-Sol on October 12. At that time it was demonstrated that the stronger Fotoceram spacers do not fracture during this ultrasonic welding step. Because of the disadvantages of Fotoceram spacers (temperature limitations and susceptibility to heat cracking during bulbing and basing operations), it was decided to utilize the alumina spacers in fabricating tubes for eventual performance tests. Additional methods of preventing fracture of the alumina spacer during welding were considered, including clamping the spacer with rubber, more precise tooling alignment, and annealing the snubbers and snubber support rods. None of these methods provided an adequate solution.

During assembly of some of the tube mounts, the cathode connectors were inadvertently reversed, requiring a reversal of pins 3 and 6 for tube testing.

The previous report discussed the short circuits (in tube mounts fabricated in the first sample lot) that occurred between the heater wires and cathode sleeve and/or between the grid laterals and anode. A few short

Table I

TABULATED HISTORY OF SAMPLE LOT OF 6080WB ELECTRON TUBE MOUNTS

Assembly* Sequence	Mounts Started	Mounts Completed	Shrinkage	Total Shrinkage	Remarks
1A Cathode tab 1B to cathode sleeve	175	175	0	0	--
Cage assembly	175	166	9	9	Open cathode tab
2 - Crimp anode eyelets) 3A Anode connectors) 3B Anode eyelets)	166	135	31	40	Very tight fit between anode rod and hole in AlSi alumina spacer. Stress in spacer caused fracture.
4A Grid eyelets	135	135	0	40	--
4B Outside grid connector	135	134	1	41	Grid plate short
4C Inside grid connector	134	133	1	42	Open cathode tab
5A-5B Heater connectors	133	133	0	42	--
6A-6C Stem lead welding	133	127	6	48	1 - open anode tab 1 - grid plate short 1 - cracked glass tube 2 - broken stem lead 1 - cracked glass flange
7A-8B Cathode connector to snubber rod	127	126	1	49	Grid-plate short
9A-9B Cathode tab to connector	126	118	8	57	4 - grid cathode shorts (Sec. I) 2 - open cathode tabs 1 - broken stem lead 1 - grid plate short
10 Getter to snubber support rod	118	118	0	57	Welded prior to assembly in tube cage
11A-11B Snubbers to snubber support rods	118	118	0	57	Resistance welded in Tung-Sol factory

* Eleventh Quarterly Progress Report, p. 8.

circuits were also observed between the grid laterals and the cathode sleeve. During this period, the probable cause of these grid-cathode shorts was discovered to be a slight twisting distortion of the cathode sleeve during ultrasonic welding of the cathode tab to the sleeve. Although the twist was essentially removed by inserting the end of the sleeve into the alumina spacer during cage assembly, residual stresses in the sleeve apparently caused sufficient distortion at operating temperatures to result in occasional contact between the grid laterals and the cathode sleeve. To eliminate grid-cathode short circuiting, a close-fitting mandrel was inserted into the cathode sleeve prior to the welding operation. With this procedure, no evidence of distortion was found, and good alignment was achieved during subsequent cage assembly. (It appears reasonable to assume that some of the grid-anode shorts in the first sample lot were caused by distortion resulting from manual assembly of the cages, where alignment was achieved by "forcing" the sleeve into the cut-out in the AlSiMag spacer.)

After the sample lot was fabricated, a Tung-Sol technician was instructed in tooling changes and alignment procedures, and the Tung-Sol operator assembled three tube mounts unassisted by Aeroprojects personnel. These mounts will not be included in the testing program.

B. Testing Program

Since the USAECOM did not define a rigid test schedule in the original contract,* Aeroprojects and Tung-Sol submitted a tentative test distribution for the 100 tubes to the Production and Procurement Directorate, Components and Materials Division, Fort Monmouth, New Jersey, by letter dated November 9, but this plan was not accepted.

A revised schedule, presented in Table II, was agreed upon at a meeting between representatives of USAECOM, Tung-Sol, and Aeroprojects, which was held at Fort Monmouth on December 9. It was also agreed that tubes with reversed cathode connectors but not otherwise defective will be incorporated into the testing program to bring the number of tubes tested to the required 100. It was further agreed that, to expedite initiation of the 2000-hour life test, authorization to perform the acceptance inspection of the 20 tubes scheduled for life tests will be given to the resident inspector at Tung-Sol by the Production and Procurement Directorate. Subsequent acceptance inspection for the remainder of the tests will be performed by the Production and Procurement Directorate.

It is anticipated that the testing program will be initiated by early February, 1966.

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* Order No. 19063-PP-62-81-H, June 1962, Note 3, Phase III-2, page 11.

Table II

SCHEDULE FOR TESTING SAMPLE LOT OF 6080WB ELECTRON TUBES

No. of Tubes	Test	MIL-E-1/1121A Paragraph No.	Reworks
20	Life - 2000 hours	4.11.4	Reading intervals at 0 hours 100 200 300 400 500 750 1000 1500 2000
20	Fatigue	See P3 of TSS, Acceptance Inspection Part 3	
15	Shock	4.9.20.5	
20	Heater cycling	4.11.7	These tubes may be non-acceptable because of defects other than opens, air, or any other defects which may affect end points.
15	Stability and survival rate	(4.11.3.1 (a) (4.11.3.1 (b)	
10	Electrical	Acceptance Inspection Parts 1-2 (Pages 2&3 of TSS)	

II. DELIVERY OF 4-KILOWATT WELDER

The 4-kilowatt ultrasonic welder, generator, and spare parts were delivered to the Frankford Arsenal, Philadelphia, Pennsylvania, on November 2, after inspection by Mr. H. Shienbloom, USAECOM, Philadelphia, and Mr. M. J. Lewis, DCD QAR DCASR 15-15, Coatesville, Pennsylvania.

III. CONCLUSIONS

A sample lot of 118 electron tube mounts has been successfully fabricated by ultrasonic welding. In order to utilize the fragile spacer now used in the 6080WB tube, the connection between snubbers and snubber support rods was made by resistance welding. After the bulbing and basing operations, the required 100 electron tubes should be available for testing.

The 4-kw ultrasonic welder was delivered to a Government agency indicated by USAECOM.

PROGRAM FOR NEXT INTERVAL

Electrical test measurements corresponding to Part 1 of MIL-E-1/1121A (9 September 1960) for 100 Type 6080WB tubes fabricated under this program will be submitted to Production and Procurement Directorate, Fort Monmouth, New Jersey, with a request to initiate acceptance inspection and testing. These preliminary tests should be concluded and the formal test program begun by early February 1966.

Because of the anticipated delay in beginning testing and the time required to complete the 2000-hour life test, a request for extension of the program until March 30, 1966, was submitted to USAECOM through DCASR, Philadelphia, Pennsylvania.

VISITS DURING THIS REPORT PERIOD

Date	Visit	Purpose
10/4-6/65 10/11-14/65 10/18-20/65 11/1/65 11/8-11/65 11/15-18/65 11/22-24/65	T. A. Walraven of Aeroprojects Incorporated visited Tung-Sol Electric Inc., Bloomfield, N. J.	Assisted in fabrication of 6080WB tube mounts.
10/27/65	H. L. McKaig, Jr., and J. G. Thomas of Aeroprojects visited R. Bell, M. Yarmovsky and N. Helmstetter at Tung-Sol.	Technical discussions and planning.
11/23/65	J. G. Thomas and C. W. Bucks (staff photographer) visited Tung-Sol.	Took photographs of completed tube mounts and test facilities for reporting purposes.
12/9/65	J. G. Thomas met with H. Shienbloom, USAECOM, Philadelphia, S. Zucker and G. F. Saverwein, USAECOM, Ft. Monmouth, and M. Yarmovsky and N. Helmstetter, Tung-Sol.	Technical discussions and testing scheduling.

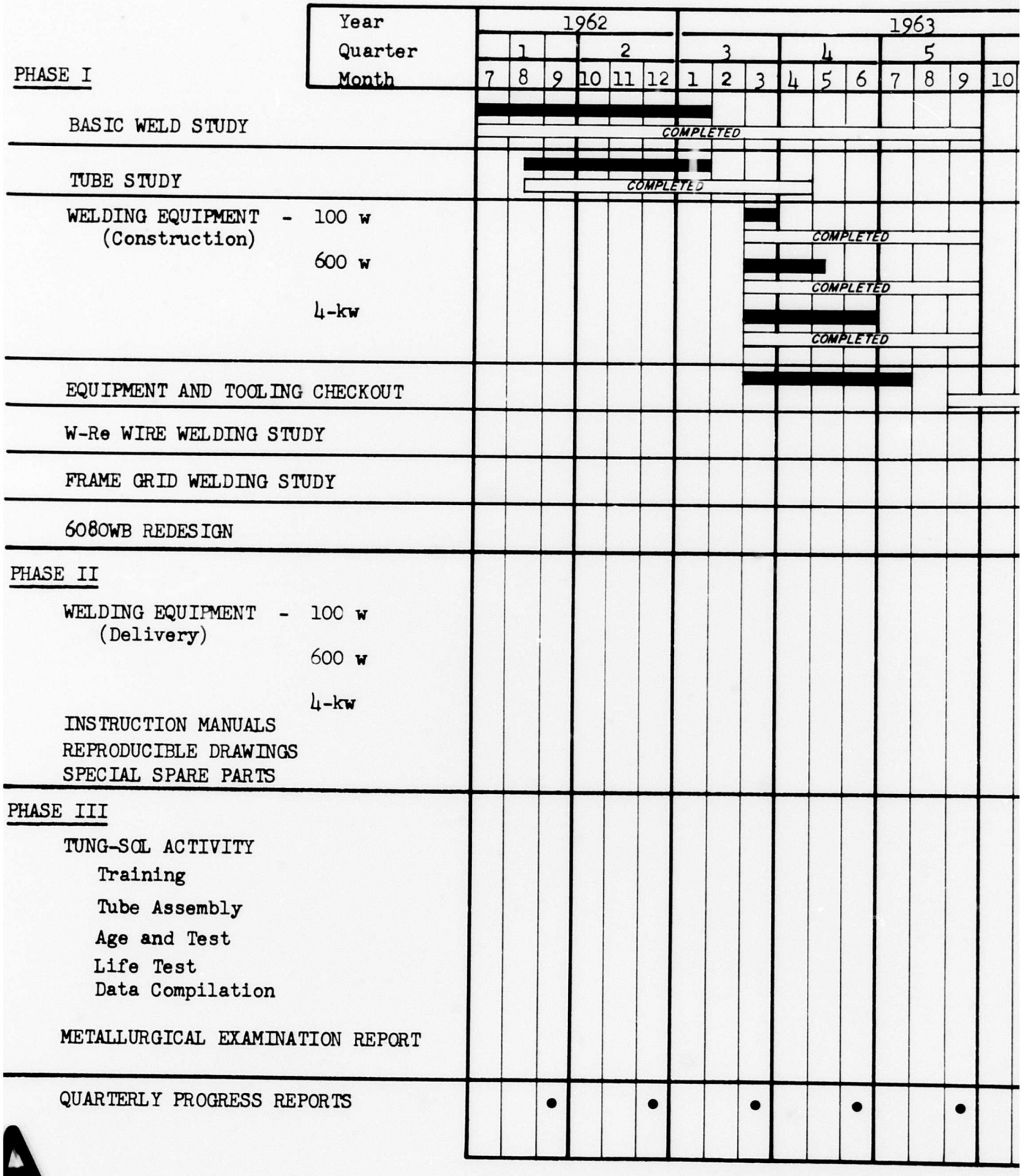
TECHNICAL MAN-HOURS

EXPENDED DURING THIS REPORT PERIOD

Aeroprojects	Project		Hours Expended During This Report Period
J. G. Thomas	Project Engineer		74
T. A. Walraven	Senior Welding Technician		191
H. L. McKaig	Vice President		8
A. L. Fuchs	Chief Design Engineer		2
N. Maropis	Physicist		1
Engineering			35
Shop			20
		Sub Total	331
Tung-Sol Electric Incorporated			
Engineering			274
		TOTAL	605

Technical surveillance of this contract is under the control of the Industrial Engineering Division, USAECOM, Philadelphia, Pennsylvania 19103. For further technical information contact Mr. Harry Shienbloom, Project Engineer (telephone number: area code 215, KI6-3200, extension 2137).

PROJECT SCH



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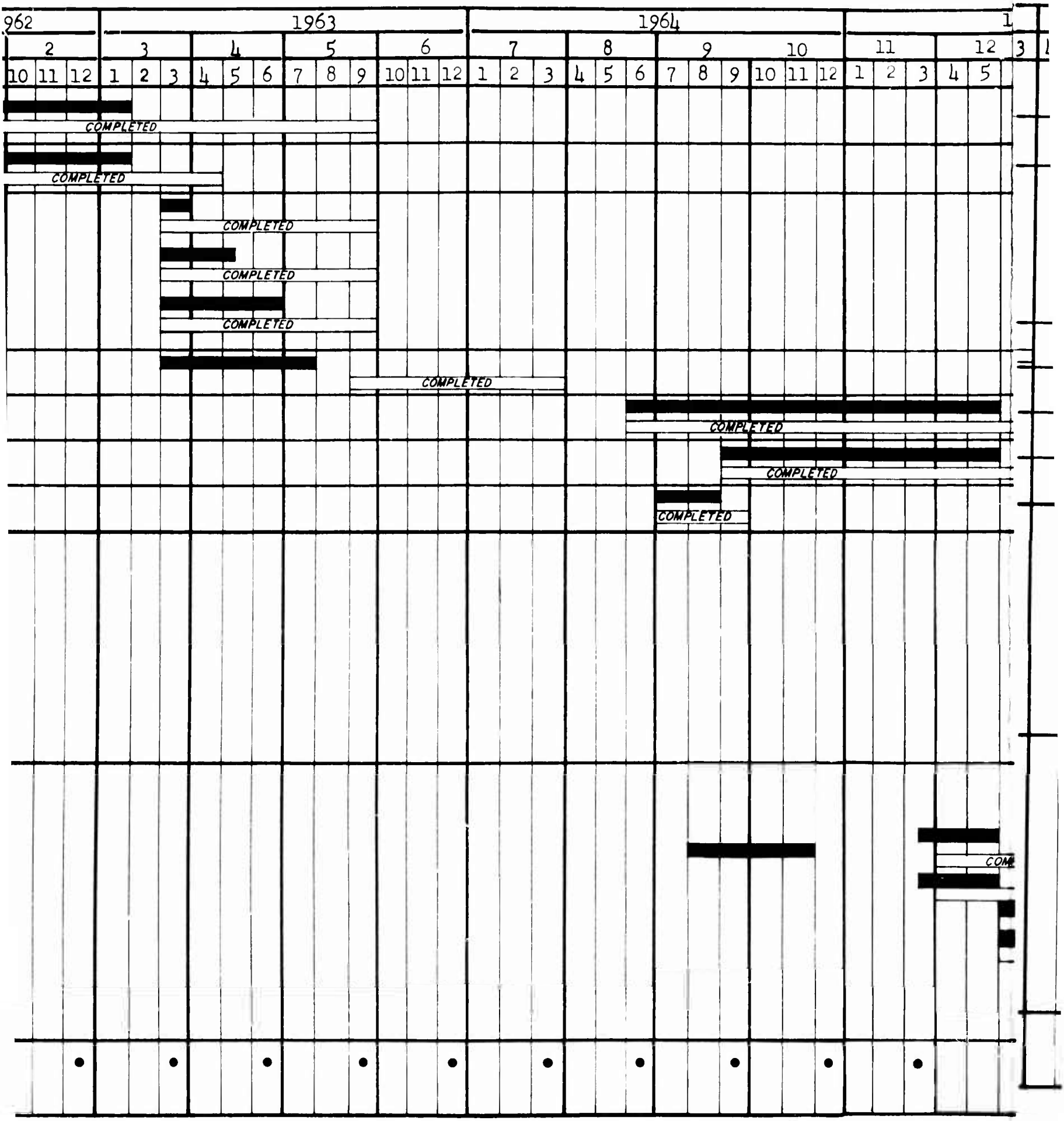
ND: Proposed Work Schedule
Work in Progress
Present Report Period

PROJECT SCHEDULE



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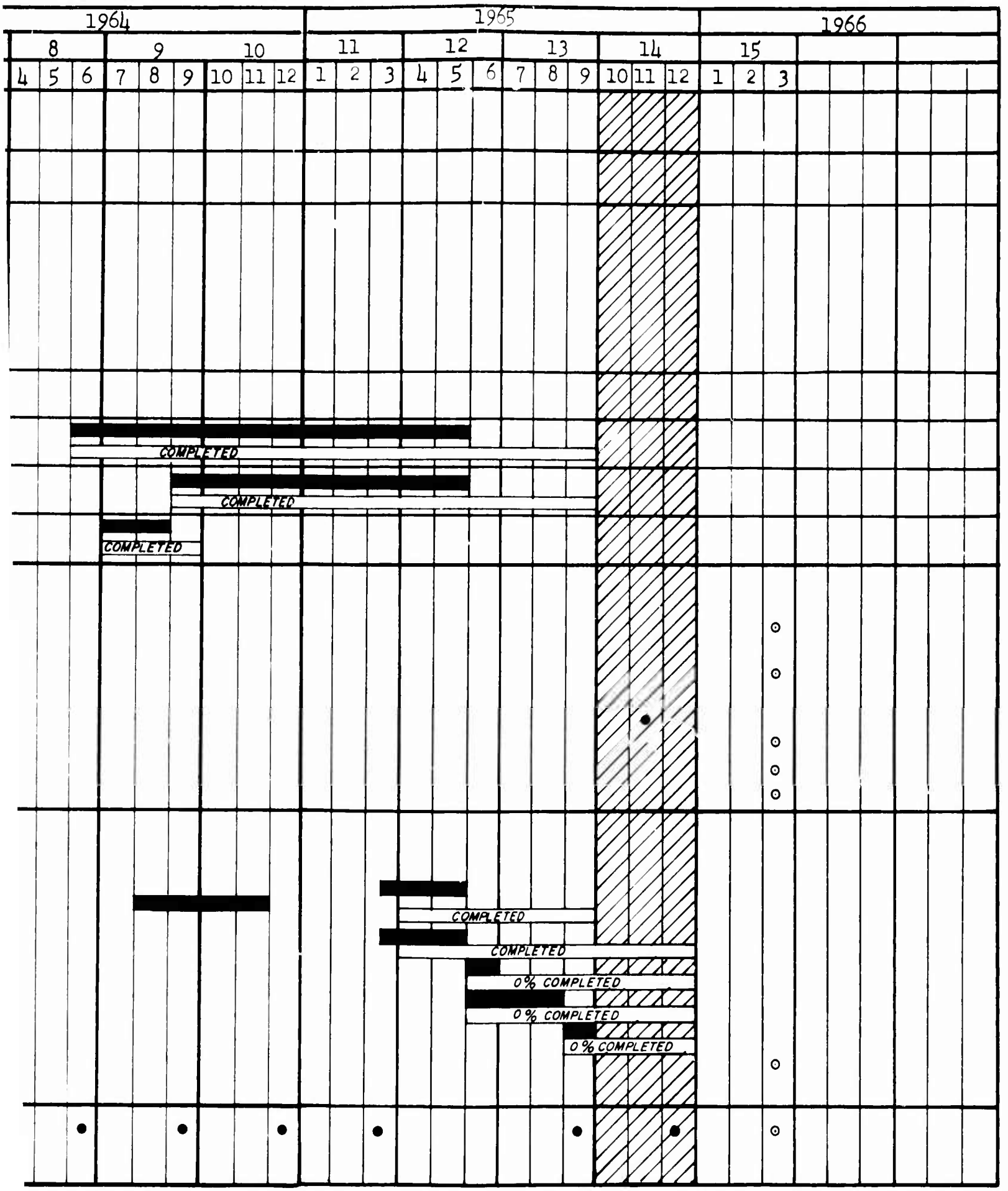
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